

**ISO KEY PROJECT:**  
**EXPLORING THE FULL RANGE OF QUASAR/AGN PROPERTIES**

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Annual Report

For Period 01 January 2002 through 31 December 2002

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## **I. Program Objectives**

While most of the work on this program has been completed, as previously reported, the portion of the program dealing with the sub topic of ISO LWS data analysis and reduction for the LWS Extragalactic Science Team and its leader, Dr. Howard Smith, is still active. This program in fact continues to generate results, and newly available computer modeling has extended the value of the datasets. As a result the team has requested and been granted an obtained a no-cost extension to this program, through December 31, 2003.

The essence of the proposal is to perform ISO spectroscopic studies, including data analysis and modeling, of star formation regions using an ensemble of archival space-based data from the Infrared Space Observatory's Long Wavelength Spectrometer and Short Wavelength Spectrometer, but including as well some other spectroscopic data bases. Four kinds of regions are considered in the studies: (1) disks around more evolved objects; (2) young, low or high mass pre-main sequence stars in star formation regions; (3) star formation in external, bright IR galaxies; and (4) the galactic center. One prime focus of the program is the OH lines in the far infrared.

The program has the following goals:

(1) refine the data analysis of ISO observations, to obtain deeper and better SNR results on selected sources. The ISO data itself underwent "pipeline 10" reductions in early 2001, and additional "hands-on data reduction packages" were supplied by the ISO teams in 2001. The Fabry-Perot database in particularly sensitive to noise can slight calibration errors.

(2) model the atomic and molecular line shapes, in particular the OH lines, using revised Monte-Carlo techniques developed by the SWAS team at the Center for Astrophysics;

(3) attend scientific meetings and workshops;

(4) do E&PO activities related to infrared astrophysics and/or spectroscopy.

## **II. Progress Report**

Work proceeded fully on track and on time this past year. We review our accomplishments in the items below.

### **A. Workshops and Conferences:**

One major item of the year program was organization of an ISO LWS workshop at Cambridge, CfA, on "ISO/LWS results on Extragalactic Astronomy from the Central Programme." This meeting was held from December 6-7, 2001. It was very successful, and it appears likely that a follow-up workshop will beheld again.

### B. Research Results:

During this period we successfully extended the SWAS (Submillimeter Wave Satellite) monte-carlo radiative transfer code to include: (1) OH; (2) the far IR lines of H<sub>2</sub>O; (3) [OI]; and are in processes of adding (4) the far infrared lines of CO. As a result we are able to model theoretically the emission and absorption from these species in molecular clouds whose structures we can adjust to ascertain the physical parameters most suitable for the various data observed. A fuller description is included in the attached preprint presented at the 2<sup>nd</sup> Maryland Conference on Far IR Astronomy, 2002.

Also during this period we began to use the "DUSTY" radiative transfer code to model the continuum emission from the same regions. The DUSTY code allows us to produce a fully thermodynamically self-consistent model of the cloud, from which we can then use the SWAS monte-carlo code to calculate the line emission properties.

Also during this period we spend a considerable effort helping to prepare for SIRTf observations, including IRAC observations of extragalactic sources, and including the proposed Early Release Observations (EROs).

"The Far Infrared Lines of OH as Molecular Cloud Diagnostics," by Smith, H.A., in the Proceedings of the 2<sup>nd</sup> Maryland Conference on Far IR Astronomy, 2002

"IR fine-Structure Line Signatures of Central Dust-Bounded Nebulae in Luminous infrared Galaxies," by Fischer, J., Allen, R., Dudley, C., Satyapal, S., Luhman, M., Wolfire, W., and Smith, H.A., in the Proceedings of the 2<sup>nd</sup> Maryland Conference on Far IR Astronomy, 2002

"Mid and Far infrared Spectroscopy of Seyfert Galaxies," by Spinoglio, L., Malkan, M., Smith, H.A., Fischer, J., in the Proceedings of the Paris Conference on AGN, 2002

"ISO/LWS Observations of the Bright Rimmed Globule IC 1396 N," Saraceno, P., Smith, H.A.,

Finally, as proposed, we spent time with our collaborator Dr. Glenn White, currently of the University of Kent, Canterbury, England, working on the Galactic Center data set. We gave an invited seminar to the Physics Department there.

### C. Advising Students and Postdocs:

During this past year the project PI has helped to advise one postdoctoral researcher, Dr. Lisa Kewley, who is now at the CfA. Her specialty is the AGN-IRB connection, and one conference proceedings has so far been published: "Do Mergers Stop Monsters?," Kewley, L., Dopita, M., and Smith, H.A., B.A.A.S., **199**, 4304, 2001.

Also in this time period the PI advised the thesis research of two graduate students, who completed their theses: (1) Dr. Sarah Leeks, of Queen Mary and Westfield College, whose thesis was, "The Long Wavelength Spectrometer: Reduction and interpretation of Data on W28 A2, a high-Mass Star-Forming Region"; and (2) Dr. Matt Bradford, of Cornell University, whose thesis was on Far Infrared Spectroscopy.

D. Other publications : In addition to the publications listed above, we were co-author of the following:

“An Infrared Study of the L1551 Star Formation Region - What We Have Learnt from ISO and the Promise for FIRST,” White, G. J., Liseau, Rene, Men'shchikov, A., Justtanont, K., Nisini, B., Benedettini, M., Caux, E., Correia, J. C., Kaufman, M., Molinari, S., Lorenzetti, D., Saraceno, P., Smith, H. A., Spinoglio, L., Tommasi, E., and Fridlund, C. V. M., *The Promise of the Herschel Space Observatory*. Eds. G.L. Pilbratt, J. Cernicharo, A.M. Heras, T. Prusti, & R. Harris. ESA-SP 460, p. 215, 2001

We acknowledge that some additional support for these research activities has come from other NASA grants.

E. E&PO Activities:

During this period HAS gave several talks to elementary school groups. He also helped to prepare the E&PO program for NGST based-instruments. He spoke at the Boston Museum of Science to a assembly of museum staff on the upcoming, cosmological, “Cosmic Questions” exhibition.

### **III. Program Plans**

During the next year of this program we intend to continue apace with the proposal, as originally presented. We anticipate no particular difficulties.